showed lung abnormalities in up to 17%, 8% and 6% of employees with under six years of work. (Exhibit 11, Charts 035a, 035b and 035c attached). While these workers likely had community exposures prior to going to work for W.R. Grace, it is also likely that exposure at Grace was their first high intensity exposure.

Consistent with these findings is Cookson (1986), Fig. 1, finding that about 20% of workers with abnormal films reached "onset of asbestosis (i.e. progression from category 0 to category 1)" (p.996) after just 8 years of work exposure to amphibole asbestos (Exhibit 12).

Disease at an early age is common in the Libby cohort. Per CARD Clinic records, 65 patients are in their 30s and 189 patients are in their 40s. This statement is based upon a total of 1,957 patients on 9/13/06.

50. DLCO (diffusion capacity) is a particularly important indicator of the severity of impairment in the Libby asbestos disease patients. We find that the DLCO defect is the leading indicator of severity in the Libby cohort, and has the greatest correlation with shortness of breath and the timing of the patient's entry to oxygen treatment. In some cases there is significant asbestos disease on the chest x-ray and only the DLCO is reduced, not the FVC or TLC. Some patients with severe shortness of breath are severe only in the DLCO defect. In Whitehouse (2004), p.224, 76% of the 123 patients

had progressive loss of lung function. Losses were about the same for FVC, TLC and DLCO at 2%-3% per year.

In the CARD mortality study, among those who died of non-malignant asbestos diseases, 47% (29/61) had only DLCO under 65 (out of FVC, TLC and DLCO).

The Rosenstock text, p.371, states: "The earliest and most sensitive finding in asbestosis is frequently a diminished diffusion capacity, which may occur in isolation or in combination with other findings." The 2005 Public Citizen comment by Dr. Michael Harbut, Dr. Philip J. Landrigan, Dr. Alan C. Whitehouse and Dr. L. Christine Oliver states that DLCO is "essential to determine how badly a person's lungs are impaired." Exh. 16.

DLCO (diffusion capacity) defect is probably associated with subpleural interstitial fibrosis. Whitehouse (2004) explains:

> Pleural changes alone are unlikely to cause a decrease in DLCO. DLCO decreases are likely to be associated with interstitial disease not apparent clinically on either plain chest radiograph or HRCT.

It does not appear that decline in diffusion capacity (DLCO) is significant in U.S. cohorts with predominately chrysotile exposure.

51. Similarly, Alfonso (2005), in an amphibole study, finds an "average rate of decline of DLCO . . . [of] about 2.2% per year [0.55/24.8] in subjects with asbestosis." Alfonso (2005), p.184, also states: "Compared

with never smokers, current smokers and ex-smokers had lower DLCO at baseline, but smoking status did not affect the change in DLCO during the follow-up period (four years for men)." Wang (1996), Figure 3 shows that asbestos exposure depresses DLCO more than does smoking.

In another amphibole study, Cookson (1983), abstract, states "[t]he ratio of transfer factor to effective alveolar volume correlated directly with the degree of pleural thickening as alveolar volume fell with increasing severity of pleural disease." Cookson, p.660, observes that reduced DLCO "in patients with asbestos induced pleural disease suggests covert parenchymal asbestosis." This is consistent with the statement from Whitehouse (2004) quoted above.

52. Chronic severe pleural pain occurs in a significant percentage of the Libby cohort at one time or another in the course of the disease. It is common in Libby patients with diffuse pleural thickening. It is often initially misunderstood by outside physicians as cardiac chest pain. Lockey (1984) similarly reports pleural pain in a cohort of workers in Ohio who were processing Libby vermiculite. Mukherjee et al (2000) report on a group of mineworkers and residents of Wittenoom, Australia, all exposed to amphibole asbestos (crocidolite). 43% (556 of 1,280) report chest pain (abstract). Yates (1996), p.304, in another amphibole study reports "chest

pain is a common feature of DPT." For non amphibole exposures, "chronic severe pleural pain is rare in patients with asbestos related pleural disease." ATS (2004), p.702. ATSDR (2008), p.36, states that with diffuse pleural thickening "the patient may experience progressive dyspnea and chest pain." The Fishman text, p.946 states regarding diffuse pleural thickening: "The diffuse nature of the lesion often leads to pulmonary symptoms, including dyspnea on exertion, chronic dry cough, and chest pain." ATS (2004) Official Statement, p.695, states that generally in asbestos disease: "a non-productive cough is commonly present." A chronic dry cough is common in Libby patients.

G. Amphibole toxicity.

53. Amphibole asbestos in general and Libby asbestos in particular are more carcinogenic and fibrogenic (productive of asbestos related disease) than is chrysotile asbestos. The Greenberg text, p.480, states:

> Several studies have also shown that worker cohorts exposed to higher concentrations of amphibole fibers have higher lung cancer rates than those exposed to similar concentrations of chrysotile asbestos. . . . This pattern of increased toxicity of amphiboles also holds true for all the other asbestos-related lung diseases (asbestosis, pleural disease, and mesothelioma).

ATS (2004) Official Statement, p.693 states that a reason given for the greater toxicity of amphiboles is that chrysotile fibers "are cleared more

efficiently than amphibole asbestos fibers, which may be retained indefinitely." ATS (2004) Official Statement, p.693. See also McDonald (2004), p.366.

54. The Fraser and Pare text, p.1075, states "exposure to amphibole fibers . . . is associated with a significantly greater risk of carcinoma compared to chrysotile exposure."

55. Amphibole asbestos appears to be at least 4x as carcinogenic as chrysotile. Hodgson et al (2000) (abstract: the "risk differential between chrysotile and the two amphibole fibers for lung cancer is thus between 1:10 and 1:50"). Antman (1993), p.373S, states: "amphiboles are about 10 times as carcinogenic as chrysotile." EPA (2003) Final Draft, p.1.4 states that: amphiboles are about 4x as carcinogenic as chrysotile; EPA (2003) Report, p.3-1 states: "according to the proposed risk assessment methodology, amphibole fibers have a five fold greater lung cancer potency than do chrysotile fibers." Also, see Stayner (1996), abstract: "there is little evidence to indicate lower lung cancer risk" for chrysotile.

56. Tremolite asbestos, which appears to be a close relative to the Libby amphibole asbestos, is considerably more carcinogenic than chrysotile asbestos. See McDonald (1997), Table 1. American Thoracic Society (1990), p.1456, states: "[a]sbestiform varieties of tremolite, are

highly carcinogenic." Case (1991), p.494, states regarding an animal study: "[s]ignificantly, the tremolite fibers were amongst the most carcinogenic tested, with actual incidence of 75% and 'percent tumor probability' of 100%." Also, McDonald (2004), calling the Libby asbestos "fibrous tremolite," found in a cohort of 406 Libby miners a 240% increase in respiratory cancer (Table 2).

57. Amphibole asbestos fibers are variously estimated at 100x to 1,000x as productive of mesothelioma as chrysotile fibers. EPA (2003) Final Draft, p.1-4 uses a factor of 1,000x ("for mesothelioma the best estimate of the coefficient (potency) for chrysotile is only 0.0013 times that for amphibole"). Hodgson (2000), abstract, uses a factor of 100x to 500x, ("at exposure levels seen in occupational cohorts, it is concluded that the exposure specific risk of mesothelioma from the three principal commercial asbestos types is broadly in the ratio of 1:100:500 for chrysotile, amosite and crocidolite respectively").

58. Amphibole fibers are more fibrogenic than are chrysotile fibers. McDonald (1999) (abstract: "this study suggests that amphibole fibers, including tremolite, are more fibrogenic than chrysotile, perhaps to the same extent that they are carcinogenic"). The same study indicates at Table 1 that Quebec tremolite asbestos fibers are at least two times as fibrogenic as

chrysotile. McDonald (2004) demonstrates that in 406 Libby miners, deaths due to non-malignant respiratory disease were at 309% of the U.S. rate.

59. Amphibole asbestos appears to be more than twice as likely to produce asbestosis and asbestos pleural disease which is radiographically progressive, than is chrysotile asbestos. Compare the following predominately chrysotile studies: Jones et al (1989), Gregor et al (1979) and Becklake et al (1979), with the following amphibole studies: Sluis-Cremer et al (1989), Cookson et al (1986), Ehrlich et al (1992), and McDonald et al (1999). See the chart "Studies on Radiographic Progression of Asbestos Disease." Exhibit 13. Jones et al (1989), abstract states: "there was . . . a greater likelihood of progression in the plant that had systematic use of some crocidolite."

In most patients with asbestos disease (including asbestos pleural disease) from exposure to amphibole asbestos, the asbestos disease is progressive. Sluis-Cremer (1989), p.852, states regarding subjects with predominately amphibole exposure, "it appears that once a dose of asbestos sufficient to initiate the disease has been retained, it is inexorably progressive." Mossman and Churg (1998), p.1669 state: "Biopersistence is probably responsible for the much greater tendency of amosite or crocidolite-induced asbestosis to progress, compared to chrysotile-induced

asbestosis."

Cookson (1986), presents Fig. I, (attached as Exhibit 12) a chart showing that 34 years after first crocidolite exposure approximately 97% of workers with abnormal films progressed radiographically to at least mild disease, 77% to at least moderate disease and 65% to at least severe disease. Crocidolite, like Libby asbestos is an amphibole. Based on my experience, I believe the numbers for the Libby workers would be similar. Cookson (1986) is consistent with the high rate of functional disease progression (76%) found in Whitehouse (2004) in 123 patients with exposures to Libby amphibole.

H. Obstructive Defect and asbestos-related disease.

60. Restrictive disease restricts what is breathed in. Obstructive disease obstructs what is breathed out.

Asbestos disease has been generally thought to be predominately a restrictive disease. The scarring in the lung lining (pleura) and in the lung air sacs and structure (parenchyma) restricts the lungs' ability to expand on inhalation.

Smoking disease is an obstructive disease. It obstructs what is breathed out. With emphysema, the lung tissue acts like an over expanded balloon. It does not constrict back to its natural form. Hence exhalation is

obstructed.

61. Smoking causes emphysema and chronic bronchitis. ATS (1995), p. 578, states:

> **Emphysema** is defined as abnormal permanent enlargement of the air spaces distal to the terminal bronchioles accompanied by destruction of their walls and without obvious fibrosis.
>
> **Chronic bronchitis** is defined as the presence of chronic productive cough for three months for at least two successive years.
>
> **Chronic obstructive pulmonary disease** (COPD) is defined as a disease state characterized by the presence of airflow obstruction due to chronic bronchitis or emphysema.

ATS (1995), p.79, states: "[o]nly about 15% of cigarette smokers develop clinically significant COPD."

62. Generally the differences between obstructive disease due to smoking and restrictive disease due to asbestos can be sorted out on pulmonary function tests. The sorting process is seriously complicated by the fact that asbestos disease often causes airway obstruction, or obstructive disease. Markowitz et al (1997) used 0.70 as the norm for persons under 60, and 0.65 for ages 60 and over. ATS/ERS (2005) "Interpretative Strategies for Lung Function Tests," p.949, states: "The practice of using 0.70 as a lower limit of the FEV1/FVC ratio results in a significant number of false positive results in males >40 years and females

>50 years."

63. It is generally accepted that ARD causes obstructive disease. The ATS (2004) Official Statement, p.710, states: "The association between airway obstruction and exposure to asbestos has been well demonstrated in non-smokers, and in some studies the association between exposure and airway obstruction is seen only among non-smokers." And, ATS (2004) Official Statement, p.708, states "asbestos exposure has long been known to be associated with an obstructive physiological abnormality." The Fishman text, p.950, states: "mild airway obstruction can also be seen in non-smokers with asbestosis." The Rosenstock text, p.371, states: "In addition to parenchymal effects, asbestos can cause air flow obstruction." The Fraser and Pare text, p.2445, states: "Many patients, however, show some degree of airway obstruction as well, as a result of asbestos-induced bronchiolar fibrosis." This means association with obstructive defect.

More recently Ohar et al (2004) reviewed data on 3,383 asbestos exposed workers in "the Selikoff registry." At page 751, the authors state: "In this analysis of 3,383 subjects, we have shown that airways obstruction is more common than restriction in asbestos exposed individuals currently undergoing evaluation. These results confirm the findings of Kilburn and colleagues (31, 39, 40, 43) and supports published clinical pathologic

correlates. Churg et al (46) have shown that asbestos exposure results in small airways disease. . . . in this study the effects of exposure to both cigarette and asbestos acted additively to induce airways obstruction."

64. The Fishman text, p.604-605, states: "the hallmark of the obstructive pattern is a reduction in the FEV_1/FVC percentage . . . Typically, all three lung volumes - residual volume, functional residual capacity, and total lung capacity are increased." Normal for FEV_1/FVC is generally 70 percent or higher. Markowitz, et al (1997), p. 102, used a ratio of 70 as normal for ages under 60 and a normal of 65 for those 60 or older. I concur with that. For hyperinflation in obstructive disease, TLC or RV must be abnormal, at over 120 percent of predicted.

65. A restrictive pattern is generally described as a reduction in forced vital capacity (FVC) and total lung capacity (TLC), with the FEV_1/FVC ratio remaining normal. The Fishman text, p.607, states: "The diagnosis of restriction is based upon the finding of a normal FEV_1/VC (ratio) and reduced VC in the setting of a reduced TLC . . . residual volume is usually reduced."

66. Very often there is an obstructive pattern associated with Libby amphibole asbestos disease. An obstructive pattern has been associated with asbestos pleural disease in the literature. ATS (2004) Official Statement, p.708 states: "Asbestos related chronic airway obstruction may

result in reduction in the FEV_1/FVC ratio, associated with reduced FEV_1 (29, 76, 113, 127)." Schwartz (1990), p.323, states "diffuse pleural thickening was associated with modest decrements in the FEV_1/FVC ratio." See also Schwartz (1990), p.323, Table 4. Obstructive defect, with a reduced FEV_1/FVC ratio, is a significant factor in many Libby patients with diffuse pleural thickening, and may become severe enough to cause significant obstructive airway disease in the absence of any other cause. As noted by Ohar et al (2004), where the asbestos exposed patient also has a history of smoking, the two may be additive in causing obstructive defect.

67. ATS (2004) Official Statement, p.697, states: "Mixed restrictive and obstructive impairment is frequently seen; isolated obstructive impairment is unusual." The Rosenstock text, p.371 states: "A mixed restrictive and obstructive impairment is also common (with greater reductions in FEV_1 than FVC, resulting in a diminished FEV_1/FVC ratio. . . . Asbestos-related airflow obstruction interacts with the effects of smoking, resulting in more pronounced obstructive changes. . . . Total lung capacity (TLC) is generally an insensitive measure of functional impairment. A result of the competing forces on TLC in mixed restrictive and obstructive impairment, with a reduction in TLC related to restrictive disease and an increase in TLC related to concurrent obstructive air trapping." ATS (2004)

Official Statement, adds "total lung capacity may be normal when both disorders are present, due to a restrictive process offsetting air trapping." Likewise "the obstructive - restrictive combination can produce an overall normal spirometric test result." 2005 Public Citizen comment by Dr. Michael Harbut, Dr. Philip J. Landrigan, Dr. Alan C. Whitehouse and Dr. L. Christine Oliver. Exh. 16.

Mixed disease is frequently seen in the Libby cohort. Interestingly, in the Markowitz (1997) study of asbestos insulators at Table 5, mixed restrictive and obstructive disease produced a higher risk of death than did restrictive disease alone or obstructive disease alone.

I. Other studies on Libby patients.

68. In 2000, I performed a review of causes of death in certain workers at the W.R. Grace mine. This was not a comprehensive study. Available death certificates and medical records were reviewed. Most of the death certificates came from the records of W.R. Grace & Co. I identified 100 workers from the W.R. Grace mine and mill who had died of asbestos related disease. Of the 100, 49 died of asbestos lung cancer, 11 died of mesothelioma and 40 died of asbestos related fibrotic disease (including asbestos pleural disease). See Exhibit 14 "Workers Dead from Asbestos Disease."

McDonald (2004) followed up on a cohort of 406 Libby miners. That study found, as of 1998, 107 total deaths, with 44 of respiratory cancer, 12 of mesothelioma and 51 of non-malignant respiratory disease (NMRD, a somewhat broader category than asbestos related disease). The numbers in McDonald (2004) and the evaluation I did appear to be quite similar.

Sullivan (2007) followed up on the entire cohort of 1,672 Libby mineworkers. Sullivan (2007), Table 1, finds as of 2001, 767 total deaths, with 99 by lung cancer, 15 by mesothelioma, 40 by asbestosis and 111 by non-malignant respiratory disease NMRD (which include the 40 asbestosis deaths).

69. The CARD Clinic in December 2005 performed a study comparing chest x-ray readings on 44 patients by CARD doctors, by ATSDR readers, and by Grace hired doctors. In the fall of 2005, the Grace Libby Medical Plan sent letters of denial to about a quarter of those enrolled in the plan. This was done through the plan administrator Health Network of America (HNA). The denials were based on chest x-ray readings by doctors hired by the Grace Plan showing no asbestos disease. The Center for Asbestos Related Disease in Libby took the first 70 letters of denial brought in by patients, and compared the CARD readings against those by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), where

available, and readings by outside doctors, where available. 44 of the 70 patients with Grace Plan denials had had chest x-rays read by the ATSDR in connection with screenings done in 2000 and 2001. See Peipins et al (2003). In 27 of 44 cases, the ATSDR confirmed the CARD finding of asbestos disease. Fourteen times the ATSDR readers on balance agreed with the Grace Plan hired doctors. There were three ties. In sum, the ATSDR was about 2x as likely to confirm the CARD readings. See Exhibit 15, Audit of HNA Denials and Downgrades of Severity of Disease (December 2005 revised).

Sixty-eight of the 70 patients denied by the Grace Plan had had chest x-rays and/or CT scans read by Dr. Steven Becker, radiologist at the St. John's Hospital in Libby. On 51 of 68 patients, Dr. Becker concurred with CARD. On the 17 where Dr. Becker did not concur, 16 of 17 CARD chest x-ray readings were confirmed by CT or other outside reading. On the one remaining, the CARD Clinic agrees that its initial reading was incorrect.

70. In 2007, an audit was done upon the chest x-ray readings by Dr. David Weill, who was hired by W.R. Grace & Co. to read chest x-rays on 380 patients of the Center for Asbestos Related Disease. In many cases Dr. Weill read chest x-rays with dates on or near the dates of chest x-ray screenings done in Libby by the ATSDR. These chest x-rays were read by independent